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RECENT STUDIES OF THE UPPER CRETACEOUS OF TENNESSEE[1]

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After an interruption of two years, due to the recent war, the Tennessee Geological Survey has taken up again the study of the Upper Cretaceous series of West Tennessee, an investigation inaugurated in 1915 under the late Dr. A. H. Purdue. The field studies, collections, and surveys necessary for this investigation are now more than three-fourths complete, and it is the purpose of this short paper to give an abstract of the general areal and stratigraphic geology of the region, to touch lightly on the large well-preserved Ripley fauna discovered in the southern part of the state in 1915, and to announce the discovery in 1919 of a large and important Ripley flora in the northern part of the state.

HISTORICAL SKETCH

The first adequate map and separation of the Upper Cretaceous series of Tennessee into formational units was published by Safford[2] in 1869. Troost and others had previously written a little of the Cretaceous of this state but had not definitely described the formations. Safford's work was based on faunal and lithologic studies and has been little changed even to the present day. In 1906 Glenn[1] published a map and gave a good, serviceable, and important account of the Upper Cretaceous of Tennessee along with his report on the geology and water resources of Tennessee and Kentucky west of the Tennessee River and of an adjacent area in Illinois. Nelson gave a short discussion of the Upper Cretaceous in connection with his studies of the clay deposits of West Tennessee[2] in 1911. The occurrence of the Tuscaloosa formation in Tennessee was shown by the work of Miser[3] on the Waynesboro Quadrangle in 1913. The McNairy sand member of the Ripley was differentiated by Stephenson[4] in 1914. In this same publication the Tennessee Upper Cretaceous deposits were correlated with beds of the same age in eastern United States. In 1916 Berry[5] published an account of about twenty-four species of fossil plants collected from the Ripley and Eutaw of McNairy and Hardin counties. In 1916 and 1917 the writer[6] published several short papers on the discovery of and some observations on a large Ripley fauna of McNairy County and a single article on the occurrence of the Tuscaloosa formation as far north as Kentucky. In 1919 Schroeder[7] gave a very brief outline of the Cretaceous in connection with his report on the Ball Clays of West Tennessee. In the latter part of 1919 Berry[8] published a very comprehensive discussion of the Upper Cretaceous Geology of Tennessee in his monograph on the *Upper Cretaceous Floras of the Eastern Gulf Region.*

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[1] Published by the permission of Wilbur A. Nelson, State Geologist of Tennessee.

[2] J. M. Safford, *Geology of Tennessee*, Nashville, 1869, map and pp. 410–21.

During 1915 and 1916 the writer mapped in detail the areal distribution of the Upper Cretaceous formations in McNairy, Decatur, and Chester counties, and in 1919 this work was carried

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[1] L. C. Glenn, *U.S.G.S. Water Supply Paper No. 164* (1906).

[2] Wilbur A. Nelson, *Tennessee Geological Survey Bull. No. 5*, Nashville, 1911.

[3] H. D. Miser, *Resources of Tennessee*, Nashville, Vol. IV, No. 3 (1913), p. 107.

[4] L. W. Stephenson, *U.S.G.S. Prof. Paper 81* (1914).

[5] E. W. Berry, *Torr. Bot. Club Bull. 43*, pp. 283–304, Pl. 16 (1916).

[6] Bruce Wade, *Proc. Acad. Nat. Sci.* (Phila., 1916), pp. 455–71, Pls. XXIII, XXIV; *Am. Jour. Sci.*, Vol. XLIII (1917), p. 293, Figs. 1, 2; *Proc. Acad. Nat. Sci.* (Phila., 1917), pp. 280–304, Pls. XVII, XVIII, XIX; *Johns Hopkins Univ. Cir.* (March, 1917), pp. 73–106.

[7] Rolf A. Schroeder, *Resources of Tennessee*, Vol. IX, No. 2 (1919).

[8] E. W. Berry, *U.S.G.S. Prof. Paper 112* (1919).

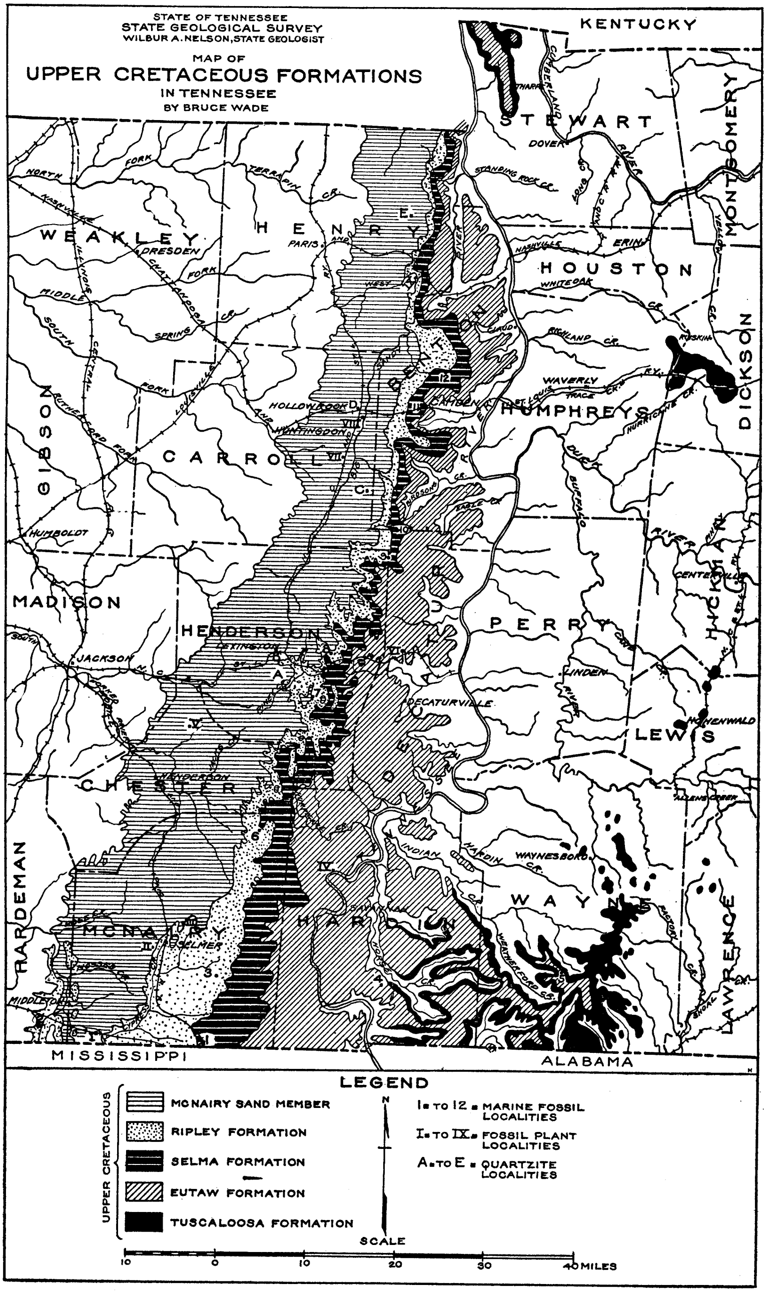

STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
WILBUR A. NELSON, STATE GEOLOGIST
MAP OF
UPPER CRETACEOUS FORMATIONS
IN TENNESSEE
BY BRUCE WADE
KENTUCKY
STEWART
MONTGOMERY
WEAKLEY
HENRY
HOUSTON
DICKSON
HUMPHREYS
BENTON
CARROLL
GIBSON
MADISON
HENDERSON
PERRY
HICKMAN
LEWIS
CHESTER
HARDEMAN
MCNAIRY
HARDIN
WAYNE
LAWRENCE
DECATUR
MISSISSIPPI
ALABAMA
DOVER
PARIS
DRESDEN
HUMBOLDT
JACKSON
HUNTINGDON
CAMDEN
WAVERLY
CENTERVILLE
LINDEN
HOHENWALD
LEXINGTON
DECATURVILLE
HENDERSON
SELMER
SAVANNAH
WAYNESBORO
MIDDLETON
LEGEND
UPPER CRETACEOUS
MCNAIRY SAND MEMBER
RIPLEY FORMATION
SELMA FORMATION
EUTAW FORMATION
TUSCALOOSA FORMATION
1 TO 12 = MARINE FOSSIL LOCALITIES
I TO IX = FOSSIL PLANT LOCALITIES
A TO E = QUARTZITE LOCALITIES
N
SCALE
10
0
10
20
30
40 MILES

FIG. 1

northward, where it was completed in Henderson and Carroll counties and in a portion of Henry County. In 1920 or the immediate future the Tennessee Geological Survey plans to complete Henry, Benton, and Hardin counties and map the outliers of Cretaceous gravels on the uplands of Stewart, Houston, Humphreys, and Dickson counties. With the field work of all these counties completed information will be in hand for a complete report on the Upper Cretaceous of Tennessee.

GENERAL GEOLOGICAL RELATIONS

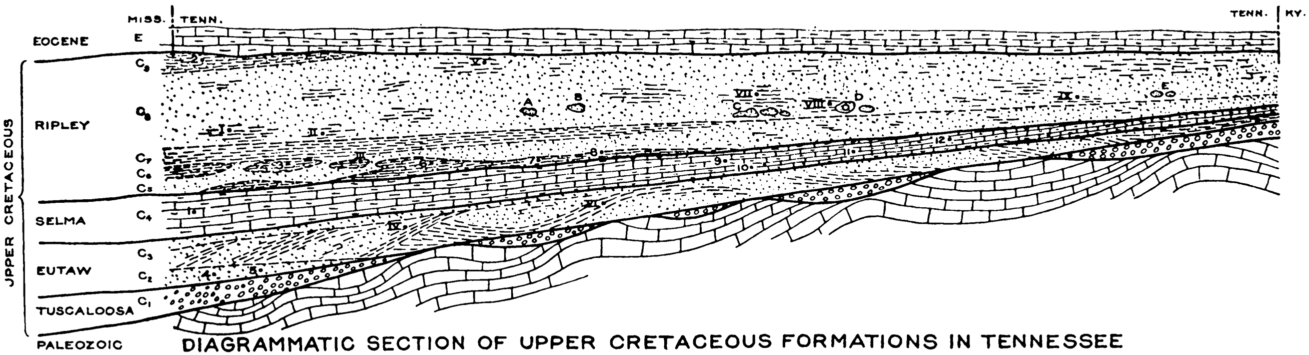
The Upper Cretaceous deposits of Tennessee outcrop in a wedge-shaped area which crosses the state in a nearly north and south direction, and lies largely west of the Tennessee River in the west-central part of the state (Fig. 1). This area is about sixty-seven miles wide along the southern boundary of the state, but narrows to the northward until at the Kentucky line it is only about fifteen miles in width. Along the southern border in Wayne, Hardin, McNairy, and Hardman counties these deposits have been segregated into the following lithologic units:

- Ripley formation
  - Owl Creek horizon or member
  - McNairy sand member
  - Ferruginous clay horizon or member
  - Coon Creek horizon or member
- Selma chalk or formation
- Eutaw formation
  - Coffee sand and clay member
  - Tombigbee sand member
- Tuscaloosa formation

In the northern part of the state these sediments diminish very greatly in thickness. The four major formational divisions may be recognized but the members or subformations lose their identity (Fig. 2).

THE TUSCALOOSA FORMATION

The Tuscaloosa formation is the basal member of the Upper Cretaceous series in the eastern gulf region of the Mississippi embayment. In western Alabama and eastern Mississippi this formation consists of irregularly bedded sands, clays, and gravels having an estimated total thickness of 1,000 feet. In *Professional*



DIAGRAMMATIC SECTION OF UPPER CRETACEOUS FORMATIONS IN TENNESSEE
FROM NORTH TO SOUTH

FIG. 2

LEGEND

E_1	Eocene, Porters Creek clay, "soapstone"
C_9	Ripley, Owl Creek horizon, fossiliferous sandy marl
C_8	Ripley, McNairy sand member, sands, clays
C_7	Ripley, ferruginous clays of McNairy County
C_6	Ripley, Coon Creek horizon, fossiliferous sandy marl
C_5	Ripley, unfossiliferous sands and clays
C_4	Selma, chalky clays varying to micaceous sandy clays
C_3	Eutaw, Coffee sands and black clays
C_2	Eutaw, Tombigbee sand member with few fossils
C_1	Tuscaloosa, gravels
P_1	Paleozoic limestones, cherts, and shales

MARINE FOSSIL LOCALITIES

1	Blue Cut on M. & O. R.R. at Tenn.-Miss. line
2	Trimms Mill, 3 miles east of Middleton
3	Sand Hill, 11 miles southeast of Selmer
4	Florence Road, 5 miles east of Nixon
5	Bear Creek, 2 miles southwest of Victory
6	Coon Creek, $3\frac{1}{2}$ miles south of Enville
7	Shady Hill, 10 miles southeast of Lexington
8	Perryville Road, 7 miles east of Lexington
9	Cub Creek, 1 mile south of Poplar Springs
10	Yellow Spring Road, 5 miles south of Holladay
11	N. C. & St. L. R.R. Cut, $2\frac{1}{2}$ miles west of Camden
12	Dickerson Place, 4 miles north of Camden

FOSSIL PLANT LOCALITIES

I	Big Cut, $1\frac{1}{2}$ miles west of Cypress
II	New Bethel Road, $2\frac{1}{2}$ miles southwest of Selmer
III	John Boyd Place, 5 miles northeast of Selmer
IV	Coffee Bluff, 4 miles north of Savannah
V	Jacks Creek Road, 4 miles south of Mifflin
VI	Perryville Road, 1 mile north of Beacon
VII	Huntington Road, $1\frac{1}{4}$ miles southwest of Buena Vista
VIII	Cooper clay pit, $1\frac{1}{2}$ miles south of Hollow Rock
IX	Perry Place, 10 miles east of Paris

QUARTZITE LOCALITIES

A	Saints Chapel, 6 miles south of Lexington
B	N. C. & St. L. R.R., 1 mile west of Lexington
C	Big Rocks, 4 miles northeast of Westport
D	Hollow Rock, $\frac{1}{2}$ mile west of Hollow Rock Junction
E	Elkhorn and Dulac Road, 4 miles north of Elkhorn

Paper 81 of the U.S. Geological Survey L. W. Stephenson has readjusted the nomenclature of the Upper Cretaceous in this region and has defined the Tuscaloosa with reference to the other formations of this series.

Toward the north the Tuscaloosa deposits become much thinner and are made up almost entirely of conglomerates which contain little sand and clay. Professor E. W. Berry[1] has made a study of this series and has found evidence in the fossil plants that the clays, in the basal part of the formation in the region of maximum thickness, are more ancient than plant-bearing clays that occur in the conglomerates about Iuka in northeastern Mississippi where the formation becomes much thinner. He shows that an Upper Cretaceous estuary existed for a long time in western Alabama before it transgressed into the northern part of Mississippi and Alabama.

Until recently the Tuscaloosa formation was thought to thin out entirely in the vicinity of the Tennessee-Alabama line. In 1913 H. D. Miser mapped the areal geology of the Waynesboro quadrangle of Tennessee and found that the Tuscaloosa was one hundred and fifty feet[2] thick and extended over a large part of Wayne County. Subsequent work by the Tennessee Geological Survey showed that remnants of the Tuscaloosa gravel occur in place of the highland rim of Tennessee as far north as northern Lewis County.[3] Farther north, during the summer of 1916, the writer encountered undescribed occurrences of the Tuscaloosa formation which show that the sediments of this transgressive phase of the Upper Cretaceous exist in a chain of local outlying areas across the state of Tennessee and as far north as the ridge west of Canton, Kentucky.[3]

An important link in this chain are the gravels which occur locally along the Nashville, Chattanooga and St. Louis Railroad between McEwen and Tennessee City and capping the higher hills in this part of Dickson County, Tennessee. A cut on the railroad about two miles east of McEwen shows, resting on chert of the St. Louis formation, about thirty feet of very compact, hard, white chert gravel which is very typical of the Tuscaloosa belt across the state. No paleontological evidence has been obtained from the gravels about McEwen to determine the age of these deposits, but after a study of the lithology as well as the geographic and topographic relations, the Tuscaloosa age of the McEwen gravels can hardly be doubted. These gravels are made up of well-rounded water-worn pebbles, most of which are one inch or less in diameter, although many are larger, often ranging up to cobbles six inches in diameter. Many individuals approach a sphere in outline, and in this respect they differ from the river gravels which are common in terraces along the western Tennessee Valley. In the river gravels of this region the individuals are often flat, elongated, and subangular. Small discoidal quartzite pebbles are often conspicuous in the terrace conglomerates. The Tuscaloosa conglomerates consist for the most part of pebbles and bowlders derived from the Lower Carboniferous cherts which are common in this part of the Mississippi basin. Water-worn sandstone and iron-oxide pebbles have not been observed in the Tuscaloosa. This is another feature which serves to distinguish the Upper Cretaceous gravels from the more recent terrace gravels in this part of the embayment region, even though the latter may rest directly on the former, as is frequently the case in the western Tennessee Valley.

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[1] E. W. Berry, *U.S.G.S. Prof. Paper No. 112* (1919).

[2] H. D. Miser, "Economic Geology of the Waynesboro Quadrangle," *Resources of Tennessee*, Vol. IV, No. 3 (1913), p. 107.

[3] Bruce Wade, "Geology of Perry County and Vicinity," *Resources of Tennessee*, Vol. IV, No. 4 (1914), p. 173; "The Occurrence of the Tuscaloosa Formation as Far North as Kentucky," *Johns Hopkins Univ. Cir.* (March, 1917).

South of McEwen, as stated above, the isolated Tuscaloosa gravel areas may be traced along the highland rim across Lewis County into Wayne and Hardin counties and farther into Mississippi and Alabama, where they are overlain by marine Eutaw deposits, and consequently paleontologic evidence may be obtained.

The Tuscaloosa extends also north of McEwen. About three miles west of Canton in Trigg County, Kentucky, at a point just east of where the Fulton and Nashville Highway crosses the divide between the Tennessee and Cumberland rivers, is an exposure of Upper Cretaceous which has already been reported. This exposure occurs in the top of the divide, which is probably more than three hundred feet above the waters of the Tennessee and Cumberland rivers. This divide is a northern extension of the western Highland Rim of Tennessee, and it is probable that further study of the plateau between the Canton and McEwen localities will reveal isolated occurrences of Tuscaloosa that form an almost unbroken chain of the remnants of this formation from Kentucky across Tennessee into Mississippi and Alabama.

A study of a map[1] of the Upper Cretaceous belt of the eastern gulf region shows that the Tennessee River flows from the east into the Cretaceous in northwestern Alabama and then takes a northerly course just east of the Cretaceous across Tennessee and Kentucky. The geological map shows that the wide Tuscaloosa belt in western Alabama and eastern Mississippi disappears entirely just north of where the Tennessee River flows into the belt, and in the same part of the state the Eutaw belt becomes abruptly narrow and disappears long before it reaches the northern limit of Tennessee. It has been previously shown that the Tuscaloosa formation, though probably not as thick and as widespread as in western Alabama and eastern Mississippi, was at one time an important formation and covered large areas in Tennessee and Kentucky, and that the Eutaw formation extended farther east and north of the areas mapped. The erosion of the western Tennessee Valley has almost entirely removed the Tuscaloosa deposits toward the north, and has likewise removed a large portion of the Eutaw deposits but to a less extent than in the case of Tuscaloosa.

THE EUTAW FORMATION

In the southern part of the state the Eutaw formation is divided into two members: the *Tombigbee sand* and the *Coffee sand.* The former is made up largely of red ferruginous sands that cap the hills of eastern Hardin County and western Wayne County. This member contains a small marine fauna near Burnsville, Mississippi, and fossils from the same horizon perhaps have been collected in Tennessee in Hardin County at a locality about five miles east of Nixon on the Florence Road and a single species from near the top of the ridge at the head of Bear Creek in Wayne County. Both of these localities are given on the sketch map (Fig. 1). This member is nowhere in Tennessee very sharply demarked from the overlying Coffee member and probably does not extend northward any farther than the northern part of Hardin County.

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[1] L. W. Stephenson, "Cretaceous Deposits of the Eastern Gulf Region," *U.S.G.S. Prof. Paper 81* (1914), map; also E. W. Berry, "Upper Cretaceous Floras of the Eastern Gulf Region," *U.S.G.S. Prof. Paper 112* (1919), map.

The *Coffee sand member* of the Eutaw was first recognized and described by Safford and has been discussed by subsequent writers. It is more than two hundred feet in thickness and is typically exposed on the Tennessee River at Coffee Bluff four miles north of Savannah in Hardin County. It is, largely a series of stratified and cross-bedded sands and clays. The sands are usually fine and of various colors, often containing an abundance of scales of mica and in places glauconite and pyrite. The sand frequently is interlaminated with thin layers of clay. Dark or black beds of clay containing very fragmentary leaves and often thick beds of lignitized logs or wood fragments are common. Some of the logs are partly or entirely silicified. Many of the larger logs are perforated by the Cretaceous wood-burrowing pelecypod *Teredo irregularis* Gabb,[1] many of which left thin irregular tubes one inch in diameter in the wood. The clays of the Coffee member are highly carbonaceous and contain an abundance of plant remains. Identifiable leaves from these clays are very rare however. Berry[2] has identified sixteen species from Coffee Bluff and ten species from about the same horizon collected at a locality on the Scotts Hill Road five and one-half miles southwest of Decaturville in Decatur County. A small collection of about seven species was made in 1919 from this same member at a locality one mile north of Beacon, Decatur County. Amber is not uncommon in the beds of wood fragments of this member of the Eutaw. A number of small pieces of amber have been collected at Coffee Bluff and at a locality on the Lexington Road two and one-half miles west of Parsons in Decatur County. One of the specimens from Coffee Bluff contains the wings of a Cretaceous caddis fly, *Dolophilus praemissus*

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[1] W. H. Gabb, *Jour. Acad. Nat. Sci.*, Vol. IV, 2d Ser. (Phila., 1860), p. 393, Pl. 68, Fig. 19.

[2] E. W. Berry, *U.S.G.S. Prof. Paper 112* (1919), p. 35.

Cockerell,[1] which Professor Cockerell says is the only known specimen of an American amber insect.

Toward the north the Eutaw formation becomes much thinner until in the vicinity of Dulac in the northern part of Henry County near the Kentucky line this formation is only about twenty feet in thickness. At Riverview, a locality about five miles south of Paducah on the Tennessee River in Kentucky, an exposure of 15 feet of typically laminated Eutaw sands and clays may be observed. In the central part of Decatur County, Tennessee, in the vicinity of Parsons and Decaturville, the basal part of the Eutaw contains irregular lenses of fine chert and quartz gravels sometimes several feet in thickness. Some other vicinities in Tennessee where the Eutaw may be studied are Camden, Holladay, Darden, Scotts Hill, Crumps Landing, Pittsburg Landing, Red Sulphur Springs, etc. The general distribution of the formation is given on the accompanying map.

THE SELMA FORMATION

The name Selma was used in Tennessee as a formational name in 1906 by Glenn,[2] who pointed out that the original term, *Selma chalk*, was applied very aptly in Mississippi and Alabama but was inappropriate in Tennessee. The Selma formation, as represented in the northern gulf embayment regions, consists of fossiliferous chalky clays and argillaceous, micaceous sands laid down during the time when the Upper Cretaceous sea was at its maximum stage of transgression. This stage may be traced across the state of Tennessee by its lithology and fauna, separating the underlying Eutaw sands and the overlying Ripley sands. There are no known unconformities in this Eutaw-Selma-Ripley series, which evidently represents a single cycle of transgression and regression of the Upper Cretaceous sea in Turonian and Senonian time. This cycle took place very slowly and probably extended over a long period of time. The cross-bedded largely non-marine sands and clays of the Eutaw represent the advancing stage of this sea. The Selma chalky sediments represent this sea at its maximum expanse at a stage when no coarse detritus was being washed in. Such a sea was especially favorable for the incoming hundreds of marine organisms which developed in great hordes among various forms, especially of mollusca. Conditions favorable for marine life in the extreme northern part of the embayment were not of long duration. Orogenic changes brought in coarse sediments and this sea began to recede, being filled in with sands which make up the Ripley formation. This recession did not take place suddenly and with uniformity but very gradually with some oscillations and sinuosities of the strand line which brought about the various members of the Ripley formation that are well developed in McNairy County and in the northern part of Mississippi.

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[1] T. D. A. Cockerell, *Proc. U.S. Nat. Mus.*, Vol. II (1916), p. 99, Fig. 6.

[2] L. C. Glenn, *U.S.G.S. Water Supply Paper 164* (1906), p. 26.

The Selma formation is a chalky clay of more than three hundred feet in thickness in the southern part of the state but near the Kentucky line it is less than fifty feet in thickness and is made up of sandy, micaceous clay. This formation is well exposed in the eastern part of McNairy County, giving rise to barren, limy hills known as "bald knobs" or glades that are frequently covered with species of Ostrea, Gryphaea, Exogyra, and Anomia. Toward the north it becomes thinner and loses its chalky nature, yet it may be readily recognized. It may be studied in the vicinity of Chesterfield in Henderson County; about two miles west of Holladay in Benton County; two and one-half miles west of Camden on the N. C. and St. L. R.R. in Benton County; four miles north of Camden on the Big Sandy Road; and about two miles west of Dulac in Henry County. Marine fossils are less abundant in the northern part of the state. In Henry and Benton counties all the exposures of this formation have not yet been examined. Among the collections now at hand for study the most northerly locality at which a collection has been made from this formation is at the Dickinson place four miles north of Camden, Benton County, on the Big Sandy Road. From this locality a fauna of about twelve species has been obtained. Some of the same species with a few additional ones have been collected in the new N. C. and St. L. R.R. cut two and one-half miles west of Camden.

Less than forty species of marine fossils are known from the Selma formation in contrast to more than three hundred and fifty known from the Ripley formation. This probably does not mean that less than forty species inhabited the Selma stage of the Upper Cretaceous sea in the embayment area, for it is most likely that the widely expanded, quiet, Selma stage of this sea was quite favorable to marine life and that a very large percentage of the Ripley species was inaugurated at that time. It does mean that conditions where so little detritus was being brought in were unfavorable for the preservation of very many Upper Cretaceous species. It may be noted that species of Ostrea, Exogyra, Gryphaea, Anomia, Paranomia, and Pecten are very common in the Selma at many localities. Also it may be noted that the shells of these species are very hard and resistant, being made up of a dense sort of cryptocrystalline shell material which withstood the corrosive and chemical effects of the sea and the attacks of a minute organism, while they were being buried in the very slowly accumulating limy muds. It is true that such species as *Ostrea larva* Lamarck and *Anomia argentia* Morton are thin and fragile, yet they are of a compact shell material and more resistant than such thick shells as a number of species of *Cucullaea*, *Crassatellites*, *Pugnellus*, *Volutomorpha*, etc. Perhaps this point may be brought out by the study of the shell materials and the occurrence of the well-known species *Paranomia scabra* (Morton)[1], which occurs in both the Ripley and the Selma. This bivalve is made up of two distinct shell materials: a thin, hard, compact, resistant outer layer similar to the shell material of certain species of Gryphaea, Ostrea, Exogyra, etc., and a softer inner layer of prismatic calcareous shell material which is similar to the shell material of most of the Ripley univalves and bivalves. In the Selma formation only the thin outer layer of *P. scabra* is found preserved. In the Ripley formation, however, at localities where there are abundant shells of various species unknown in the Selma both the inner and outer layers of *Paranomia scabra* occur perfectly preserved. Thus if the entire shell of this species were as soft as the inner layer this species too would be unknown in the Selma.

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[1] S. G. Morton, *Synopsis of the Original Remains of the Cretaceous Group of the United States* (1834), p. 62.

THE RIPLEY FORMATION

The Ripley formation has the greatest areal distribution of any of the Upper Cretaceous formations in Tennessee. It is extensively developed both in the northern and southern part of the state. It outcrops in a broad belt in general along the Tennessee-Mississippi divide, a hilly and sandy area with little fertility or agricultural productiveness. In certain localities this formation is highly fossiliferous and contains an abundance of beautifully preserved animal and plant remains, but these are rather exceptional, for the Ripley of Tennessee is made up largely of non-fossiliferous sands and clays. In the southern part of the state the Ripley formation has been segregated into the following lithologic and faunal members or horizons: Owl Creek horizon or member; McNairy sand member; ferruginous clay horizon or member; Coon Creek horizon or member. In the central and northern parts of the state the Owl Creek member and the ferruginous clay member lose their identity and become a part of the McNairy sand member which constitutes by far the major portion of the Tennessee Ripley.

The Coon Creek horizon or member in the northern part of the state consists of ferruginous sands with few or no fossils, but in the southern part of the state it is glauconitic and fossiliferous. In some localities it contains beds of sandy marl which have yielded a very large fauna of beautiful and unusually well-preserved marine fossils. An announcement of the discovery of these fossils and a somewhat detailed description of the Coon Creek locality together with some preliminary observations on the fauna were published in the March, 1917, number of the *Johns Hopkins University Circular*. Figures and plates of this fauna of about three hundred and fifty species are now being made for a monograph report by the author to be published by the United States Geological Survey.

The occurrence of so many well-preserved shells in deposits as old as the Cretaceous is uncommon. No other single locality in the American Cretaceous, that has yet been studied, has produced so large an assemblage of such excellent fossils, which even rival best Cretaceous collections from any of the well-known European or Indian localities. Some of the well-known Cretaceous localities that have yielded prolific faunas which may be cited for comparison and reference are: Owl Creek, Mississippi,[1] Ripley formation; Eufaula, Alabama,[1] Ripley formation; Patula Creek, Georgia,[1] Ripley formation; Snow Hill, North Carolina,[2] Black Creek formation; Brightseat, Maryland,[3] Monmouth formation; Mount Laurel, New Jersey,[4] Monmouth formation; Fox Hills, Moreau River, etc., western interior,[5] Montana formation; Huerfano Park, Pugnellus Sandstone, Colorado,[6] Colorado formation; Phoenix, Oregon,[7] Lower Chico series; Queen Charlotte Islands, Canada,[8] Chico series; Ferrocarril de Tampico á San Luis Potosí, Mexico,[9] Lower Senonian; Lastro, Sergipe, Brazil,[10] Senonian; Quiriquina, Chili,[11] Senonian; Pondoland, South Africa,[12] Senonian; Chargeh Oasis, Libyan Desert,[13] Danian; Central Tunis, Africa,[14] Cenomanian Atherfield, England,[15] Wealden; Blackdown, England,[15] Upper Greensand; Aachen, Germany,[16] Senonian; Kunroed, Belgium,[17]

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[1] L. W. Stephenson, *U.S.G.S. Prof. Paper 81*, Tables 2, 8; T. A. Conrad, *Jour. Acad. Nat. Sci.*, Vol. III, 2d Ser. (Phila., 1858), pp. 323–36; Vol. IV, 2d Ser. (1860), pp. 275–98.

[2] L. W. Stephenson, *Upper Cretaceous Paleontology of North Carolina.* Manuscript in press; T. A. Conrad, *Rept. Geological Survey of North Carolina*, Vol. I, App. A (1875).

[3] J. A. Gardner, *Maryland Geological Survey, Upper Cretaceous Volume* (1916).

[4] Stuart Weller, *Pal. New Jersey*, Vol. IV (1907), pp. 128–36, etc.

[5] Meek and Hayden, *U.S.G.S. Terr.*, Vol. IX (1876).

[6] T. W. Stanton, *U.S. Geol. Sur. Bull. No. 106* (1893).

[7] F. M. Anderson, *Proc. Cal. Acad. of Sci.*, Vol. II, 3d Ser. (1902).

[8] J. F. Whiteaves, *Geol. Sur. Can. Meso. Fos.*, Vol. I (1876).

[9] E. Böse, *Instituto Geologico de Mexico*, Bol. 24 (1906).

[10] C. A. White, *Archivos de Museu Nacional do Rio de Janeiro*, Vol. VII (1888).

[11] O. Wilchens, *Neues Jahrb. für Min., Geol., und Pal.*, Band XVIII (1904), p. 272.

[12] H. Woods, *Ann. South African Museum*, Vol. IV, Part VII (1906).

[13] A. Quass, *Beitrag zur Kenntnis der Fauna der obersten Kreidebildungen in der Libyischen Wüste* (München, 1902).

[14] L. Pervinquière, *Etudes de Paléontologie Tunisienne*, Vol. I and II (Paris, 1912).

[15] H. Woods, "Cret. Lamel.," *Pal. Soc. London*, Vols. I, II (1899–1913).

[16] E. Holzapfel, *Palaeontographica*, Bände XXXIV, XXXV (1888, 1889).

[17] F. Kaunhowen, *Palaeontologische Abhandlungen*, neue folge, Band IV (1897).

Maestrichtian; Le Mans, France,[1] Cenomanian; Gosau, Austria,[2] Turonian; Conarapollia, India,[3] Arrialoor group.

An analysis of the Coon Creek fauna and comparisons with related faunas will appear in the monograph report. A new species of Scaphites closely related to the well-known form *Scaphites nodosus* Owen[4] is perhaps as diagnostic and as representative a form as any single species of the Coon Creek fauna that might be mentioned. The *nodose* group of Scaphites are widely distributed in the marine Senonian deposits of the Upper Cretaceous of the world. They have been extensively studied and are an important factor in intercontinental correlations[5] of these deposits.

The ferruginous clay horizon or member of the Ripley is well exposed in a cut on the M. and O. R.R. just south of Falcon in McNairy County. This is a series of stratified micaceous clays about one hundred feet in thickness with numerous concretions of limonite which are very conspicuous on the eroded slopes in the central part of McNairy County. A scant and dwarfed marine fauna has been obtained from this clay in the southern part of the state. Toward the north this clay becomes sandy, loses its identity, and merges into the McNairy sand.

The McNairy sand member is a thick series of non-marine sands and clays with a few irregular occurrences of quartzites. As is shown on the accompanying map the McNairy sand covers a wide belt of the Cretaceous area and is equally developed in both the northern and southern portions of the state. This member was first differentiated and described by Stephenson[6] in 1914. It is typically exposed at a cut on the Southern Railroad near

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[1] A. d'Orbigny, *Paléontologie Française, Terrains Crétacés* (Paris, 1840–60).

[2] F. Zekeli, *Abhandl. der k.k. Geol. Reichs.*, Band I (1852); K. A. Zittel, "Die Bivalven der Gosaugebilde," *Denkschr. d.k. Akad. d. Wissensch. Wien. Math.-nat. classe*, Vols. XXIV and XXV (1865–66).

[3] F. Stoliczka, "Pal. Indica, Cretaceous Faunas, South India," *Geol. Survey India* (1865–70).

[4] D. D. Owen, *Rept. Geol. Sur. Iowa, Wis., Minn.*, p. 580, Table 8, Fig. 4 (1852); F. B. Meek, *U.S.G.S. Terr.*, Vol. IX, pp. 426–30, pls. and figs (1876).

[5] F. Frech, "Ueber Scaphites," *Centralblatt Min., Geol., Pal.*, No. 18 (1915), pp. 553–68; No. 21, pp. 617–21.

E. Kayser, *Lehrbuch der Geologie*, Teil II, 5. Auf., pp. 534–62 (1913).

[6] L. W. Stephenson, *U.S.G.S. Prof. Paper 81* (1914).

Cypress, McNairy County. Clay is mined from the McNairy sand at several localities in Carroll and Henry counties.[1] Conspicuous large masses of quartzite or very hard, fine-grained, white sandstone of irregular occurrence are found at several isolated localities in Henderson, Carroll, and Henry counties in the lower part of the McNairy sand member. The more important quartzite localities are shown on the accompanying map and section. These masses are exceedingly resistant to erosive agencies and are often left lying bare on the surface after the softer sands and clays which formerly inclosed these masses have been washed away. They occur in irregular, cavernous, and often grotesque shapes that attract the attention of travelers and the natives in these regions. The well-known "hollow rock" at Hollow Rock Junction in Carroll County has served as a landmark since early settlers first went into that part of the state. The most extensive occurrences of this quartzite are two miles south of Dollar in Carroll County where masses as large as a two-story house may be observed in an area of two or three square miles. The origin of these masses is due to the cementation of local accumulations of very fine and pure quartz sands deposited along with the other McNairy sediments. Large masses of highly ferruginous hard sandstones are common in the Ripley, but the quartzites under discussion are characterized by a very low iron content. Similar occurrences of quartzites are known in the Eocene of Tennessee, Arkansas, and Mississippi.

Fossils are quite rare in the McNairy sand, and the few that have been known until quite recently were about twelve species of plants collected from near Selmer[2] and Big Cut[2] in McNairy County and three species from the southeastern part of Henry County.[2] In 1919 Schroeder noted the abundance of fossil leaf impressions in the Cooper clay pit[3] near Hollow Rock, Carroll County, but made no collection of these plants. During the latter part of the summer of 1919 the writer made large collections of fossil plants from the Cooper clay pit and from some new localities, namely, three miles south of Mifflin in Chester County, near Beuna Vista in Carroll County, and from the Perry Place, ten miles east of Paris on the Manlyville Road, in Henry County. These collections have all been submitted to Professor Berry, and he is now completing a monograph report on this heretofore unknown, large, Ripley flora of more than one hundred and twenty species. The majority and the best specimens of this plant material came from the Perry Place. This locality is a small gully exposure of a lens of clay several feet in thickness on a farm belonging to Dr. J. R. Perry. The fossil leaves occur in a two-foot layer of dark brownish clay in the very bottom of the gully. This locality is about eighteen miles southeast of Puryear and about the same distance northeast of the Grable clay pit. Puryear is an Eocene plant locality made famous by the recent studies of Professor Berry,[1] who has collected and described from the Wilcox clays of Puryear the largest and most beautiful fossil flora known in America. The Grable clay pit is a recent opening in the Wilcox clay about twenty miles southwest of Puryear and contains a great wealth of fossil plants. Due to the recent workings at the Grable and due to the filling in of some of the old classic pits, there is at present no locality in west Tennessee where so many beautiful fossil plants can be obtained as at the Grable pit and the neighboring Adkins pit. Of the Ripley plant localities next to the Perry Place in importance is the Cooper clay pit. All the McNairy plant localities are shown on the accompanying map and diagrammatic section.

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[1] W. A. Nelson, *Tenn. Geol. Sur. Bull. No.* 5 (1911).

[2] E. W. Berry, *Torrey Bot. Club Bull. 43*, pp. 283-304 (1916); *U.S.G.S. Prof. Paper 112*, pp. 38, 39 (1919).

[3] R. A. Schroeder, "Res. of Tenn.," *Tenn. Geol. Sur.*, Vol. IX, No. 2 (1919), p. 154.

Stratigraphically above the McNairy sand member in southwestern McNairy and eastern Hardeman counties is the Owl Creek horizon or member. This is a series of micaceous sands and marls about fifty feet in thickness in Tennessee that contain a portion of the Owl Creek marine fauna. About fifty species have been collected at Trimms Mill and other localities on Muddy Creek in Hardeman County. Among these is the Owl Creek form, *Scaphites iris* Conrad.[2] This northern extension of the Owl

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[1] E. W. Berry, *U.S.G.S. Prof. Paper 91* (1916).

[2] T. A. Conrad, *Jour. Acad. Nat. Sci.*, Vol. III, 2d Ser. (Phila., 1858), p. 335, Pl. 35, Fig. 23.

Creek beds does not extend far into Tennessee. It is merely one of the major oscillatory stages of the retreating Ripley sea as it withdrew slowly from the northern part of the Mississippi embayment area.

The general stratigraphic and areal relations of the Tennessee Upper Cretaceous are best summarized on the accompanying map and diagrammatic section. These show the positions of the large Ripley faunas and floras with reference to the rest of the Tennessee Cretaceous. The most important scientific results of the recent studies of the Tennessee Cretaceous are the unearthing of the Coon Creek fauna and the Perry Place and Hollow Rock flora. These abundant and excellent animal and plant remains are of nearly the same age and at the base of the Ripley. They not only mark definitely the lower Ripley with two different lines of evidence, making this a very important horizon for reference in subsequent studies and intercontinental correlations of the Upper Cretaceous, but also these well-preserved remains furnish certain biological evidences that are of some importance in the systematic classification of a few of the ancient animals and plants of Cretaceous times.